CHAPTER 19
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Easy Mounting Aerobic Roller System: An Independent Wheelchair Roller

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INTRODUCTION

Wheelchair racing has become increasingly popular and as with any sport, the athlete must be able to train on a regular schedule to stay competitive. For wheelchair racers, this means practicing on the open road or on an outdoor track. If a track is not available, or if road conditions are deemed unacceptable by the athlete (i.e. snow, city traffic, and extreme cold weather), then another means of training is needed.

The need for wheelchair exercisers by manual wheelchair users is great, but as with most specialized health equipment, the cost of a quality device is prohibitive. There are several low-cost commercial products available, but they are neither user independent or easy to use. The client, a wheelchair racer at the Massachusetts Hospital School, needs an independent easy to use system that provides both aerobic and strengthening exercise. For this reason, the creation of a low-cost, yet high quality treadmill design, was explored through background research, and design development.

SUMMARY OF IMPACT

Aerobic training is a critical component in the conditioning of an athlete. For the wheelchair user, the ability to train using the wheelchair in a stationary roller system is a convenient and beneficial strategy. However, many performance criteria need to be met by a roller system to make it a practical and effective training tool for these athletes (such as reproduction of actual on-road feel; variable resistance options; ease of use and affordability). A highly accomplished, 17-year-old male wheelchair athlete at the Massachusetts Hospital School was the subject for the development of a device which successfully met these standards, the EMARS (Easy Mounting Aerobic Roller System).

The device has offered this student many advantages over a variety of commercial roller systems that he had previously trained on, including a greater real-surface experience, a more versatile range of variable resistance settings and a configuration that is easier to mount and use. The EMARS is not only providing this athlete with a more enjoyable and effective workout, but its greater flexibility and accessibility will enable a number of wheelchair users as the Massachusetts Hospital School with less training experience to derive benefits from aerobic condition on the device.

TECHNICAL DESCRIPTION

The Easy Mounting Aerobic Roller System (EMARS) is an entirely user independent system. There are four main components to the system: the ramp, the rollers, the frame and the magnetic unit. The frame is designed for a low profile of 3.25 inches permitting a slope of 1/4 for the ramp that offers user independence. Two rollers are used with deflection devices that eliminate the need for a clamping mechanism. Finally, a magnetic unit is coupled to the back roller to permit seven levels of workouts accommodating carious levels of user ability. The magnetic unit is also be decoupled to allow for hand stroke analysis.

Unlike other roller systems, the EMARS has a solid frame onto which the rollers are mounted. This keeps the rollers properly aligned and prevents drifting. The base consists of a flat rectangle made from 0.25-inch thick strips of aluminum 6061-T6 stock. Triangular comer braces as well as a center strip is welded to the frame to ensure accurate alignment for the base rollers. Supports are added to hold the shafts for the rollers and platform. Each end of the shafts is inserted into holes in the supports. These holes are created between two blocks that are hinged and hold the shaft in place with two bolts. This allows for easy assembly and disassembly for transportation or the replacement of the rollers. The supports are also designed so that once resting on the rollers, the back wheel of a standard wheelchair (24" diameter) are level with the top of the platform. This provides a level-operating surface for comfort and improved posture.

The core of the roller assembly consists of a hardened steel shaft that runs the length of the roller. This ensured that the ends of the roller assembly is be collinear and helps with alignment. The shaft diameter chosen is 0.5 inches. NICE brand roller bearings are used, rated for an angular velocity of 1200 rpm with a load capacity of 92 pounds. Previously, needle bearings press fit into self aligning spherical bearings were used. However, these bearings were rated at an operating speed of 4500 rpm and did not allow free spin below that rpm. This made for uncomfortable training because the rear wheel would stop spinning in less time than it would take the user to complete the recovery phase of the stroke. The rollers are constructed of aluminum 6061-T6 due to the higher deflection of other plastics that were tested. Two nylon devices are placed on each roller along the centerline, 18" apart. These devices help keep the wheelchair from drifting side to side and accommodate wheelchairs ranging in width from 19" to 28" with either a slanted structure as found on racing wheelchairs or the standard manual chairs.

A commercial magnetic device was attached to the EMARS (Nashbar Model VT-EM). The device supplies resistance to the rear roller through a belt and pulley system. A mounting block is welded to the frame to support the magnetic resistance device.

Both the ramp and the platform are constructed from 3/4" Lauan plywood. The platform is designed for a height of 3.25". This low profile allowed for a short (15") ramp with a practical 1/4 rise to run ratio. The large platform (40" x 38") allows the user to train using standard wheelchairs, as well as longer racing wheelchairs and still maintain a level operating surface. For standard wheelchairs, if the user is not comfortable with rolling backwards up the ramp, the platform provides enough space for the user to roll up the ramp forward, and then turn around before mounting the rollers. The legs of the platform (3.25" x 20") are reinforced with 1-1/2" L brackets. On the end opposite the ramp is a shaft which attaches to the frame. The shaft is held in place under the platform using conduit brackets, and the ends of the shaft are clamped to the frame through support blocks, similar to the rollers. For storage, the ramp is folded under and the platform rotated up on its shaft and leaned against a wall. This provides for easy storage using a small floor space for residential applications. By removing the platform from the frame using a 1/2" socket and driver, the device fits into a standard sized automobile trunk for transportation. The overall combined weight of the device is approximately 60 pounds.

The total cost of the roller system was $236.

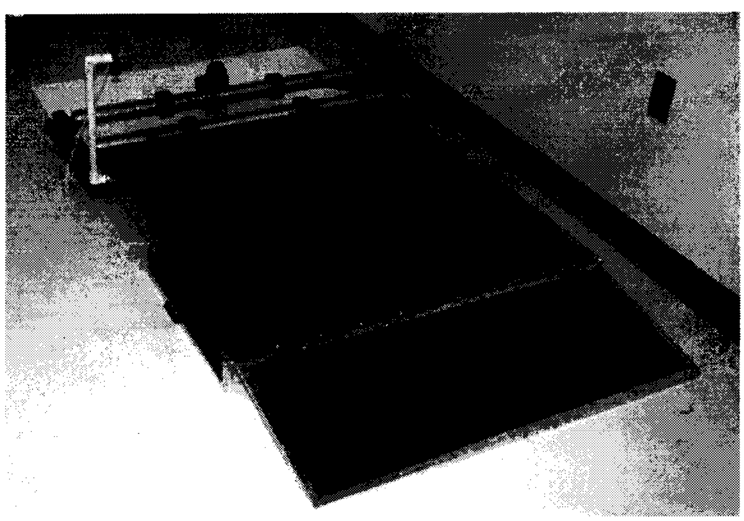

Figure 19.1. The EMARS Wheelchair Roller.

Design of a Shock Absorbing: Bumper System for Power Wheelchairs

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INTRODUCTION

The Massachusetts Hospital School is a school for students with various disabilities. Although most of the students are confined to wheelchairs, they act like typical kids. Because these students are very active, their wheelchairs experience a great deal of abuse. This is especially true during highly interactive sports, such as soccer, football, basketball, and hockey. While playing such sports, the children tend to run into each other with their wheelchairs. The impact during collisions usually occurs around the footrest area. As a result of repeated impacts, the footrests and footrest mounts begin to yield or fracture and ultimately become separated from the wheelchair frame. The child's feet are also prone to injury, such as broken bones, depending on the exact place of impact. Because many of the students at MHS lack feeling in their legs, broken bones can remain undetected for days until signs of infection appear. Both of these are serious problems that need to be addressed. Therefore, there is a need to design a new footrest system for the wheelchair that must be able to withstand repeated impacts and protect the feet of the user.

SUMMARY OF IMPACT

The evolution of the power wheelchair has made many exciting opportunities available to individuals unable to walk or use a manual wheelchair due to physical disabilities. However, with the advent of faster, more responsive chairs and the more active lifestyles of users comes the need to develop safety features which address the significant forces generated by the inevitable impacts of these devices with obstacles in their environment (i.e.: walls, doors, people, other wheelchairs, etc.). The wheelchair user, the structural components of the wheelchair and the obstacles all suffer serious damage because of an undampened collision.

The development of a shock absorption bumper system for the front of a power wheelchair operated by an l&year-old young man with muscular dystrophy at the Massachusetts Hospital School has successfully addressed these issues. The bumper system readily absorbs a portion of the forces generated by a direct impact between the wheelchair and a solid object and diffuses the stresses. The device has given the student the potential to participate more fully in campus wide activities while minimizing the risks of physical harm to his legs and reducing the frequency and costs of repairs to his power wheelchair. With further development of the bumper system, the device could

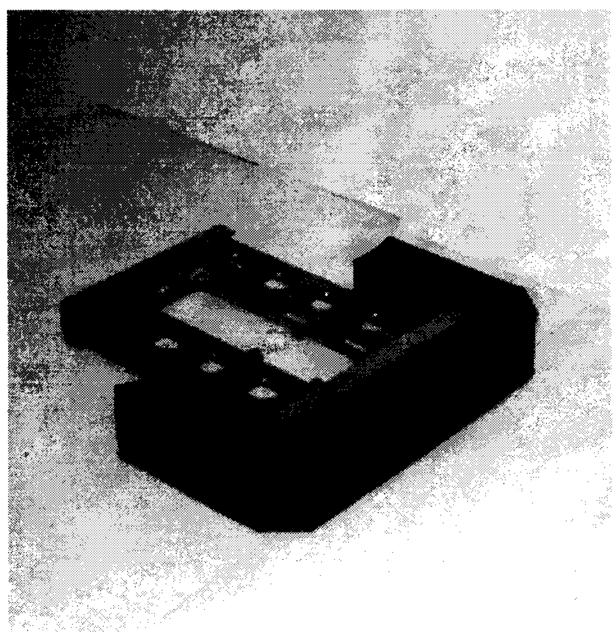

Figure 19.2. Wheelchair Bumper.

provide the option of either being fixed to a wheelchair for constant use or be mounted intermittently at the user's discretion for special protection during particularly high-impact activities.

TECHNICAL DESCRIPTION

Many conceptual designs were developed to absorb energy of a frontal impact. Iteration in the design process allowed for the most feasible design that would meet the greatest number of task specifications. This design uses a rigid aluminum bumper mounted on springs to absorb energy globally. The rigid bumper is covered with a layer of foam to distribute the energy and protects objects that are being hit by the wheelchair. The design absorbs both frontal and side impacts without transmitting excessive force to the wheelchair frame. The bumper does this by translating forwards and backwards in slots as well as side to side with elastomer springs in the front and on both sides.

This design was analyzed using a computer model to find the spring constants needed to absorb the energy of impacts. Once the analysis was complete, the design was manufactured. The completed design was tested in house to make a comparison between calculated and actual energy absorption. The bumper absorbed close to the expected amount of energy. The results of the testing were used to find forces that would be transmitted to the wheelchair frame. The forces applied to the frame were not large enough to cause large moments on the tubes of the wheelchair frame. A fatigue analysis was done on this frame member and it was found that the frame would theoretically be able to withstand an infinite number of impacts.

There are two main components of the bumper system; the actual shock absorbing bumper assembly and a bumper frame sub-assembly that the bumper component attaches to. The bumper component is designed to absorb most of the energy in an impact using four different types of components. These are TecsPak elastomers, urethane, closed cell foam, and neoprene rubber. These components are mounted on an aluminum channel with a 3-inch base.

The TecsPak elastomers are the main energy absorbers in the final prototype. They are used to absorb energy globally in frontal impacts. The GBR-7 TecsPak bumper is the selected model of the bumper component. The final design uses five of these components mounted in parallel to the 3 inch base aluminum channel.

Urethane elastomers are used to globally absorb energy in side impacts. Each side uses two of these components mounted parallel to each other. Each is guided by a shoulder bolt that slides in slots attached to the aluminum frame sub-assembly.

The front of the bumper assembly is covered with 1.25-inch thick medium hard closed cell foam. The foam is a blend of EPDM, neoprene, and SBR. It is used to absorb energy locally in both frontal and side impacts. There is an energy absorption of 60 in*lb per cubic inch of foam. The foam also serves as a cushion to prevent damage to objects being hit by the client. The bumper sub-assembly uses an outer layer of foam attached to 4 inch base aluminum channel by silicon glue.

A layer of 1/32-inch neoprene synthetic rubber covers the medium hard closed cell foam. While it absorbs a small amount of impact energy, the rubber is used primarily to protect the foam from being damaged. The rubber wraps around the foam and is attached to the 4-inch base aluminum channel by silicon glue.

The sub-assembly is made from aluminum. There are two pieces of three-inch channel, which are joined to a four-inch channel using TIG welds. The aluminum sub-assembly is rigidly attached to the wheel chair frame using block clamps. The sub-assembly supports the bumper and provides a base on which to mount the elastomer springs that absorbs the energy of impacts. Slots are machined in the sub-assembly allowing the bumper to slide forwards and backwards. Shoulder bolts are bolted into the bumper and translate in the slots. The system of slots and shoulder bolts permits the bumper to translate in both the forward/backward directions as well as laterally (side to side). This translation allows absorption of energy in both front and side impacts. The shoulder bolts can slide backward 2.5 inches and can slide 1 inch to either the right or the left. The sub-assembly attaches to the wheelchair using four block clamps that fit around the frame of the wheelchair and are bolted to the sub-frame of the bumper.

The final cost of the bumper system is $354.